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THE MOBILE INTERCONTINENTAL BALLISTIC MISSILE (MICBM) SIMULATION

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ABSTRACT

The purpose of this project was to investigate the capability of blending traditional discrete event simulation techniques with artificial intelligence technology. In order to fully demonstrate the capabilities of such a simulation environment, a difficult class of simulation problem was selected for the project: a military C³ (Command, Control, and Communication) simulation. The hardware chosen for the project was a Symbolics* LISP machine running an artificial intelligence shell called Knowledge Engineering Environment (KEE)†. The authors were pleased to conclude that this environment provided a powerful simulation capability in which human decision-making processes could be readily represented.

PROJECT DESCRIPTION

The Physical System Modeled

One of the military systems that has been proposed for national defense is the Midgetman Mobile Intercontinental Ballistic Missile (MICBM) system. The system as proposed would consist of a number of mobile launcher organizations that could be deployed throughout a region of the United States. A launcher organization would be comprised of the launcher vehicle and other support equipment and personnel.

Since the MICBM system does not exist, the authors "designed" the hypothetical MICBM system, specifying the physical assets and attributes of a launcher organization. The following is a list of the physical equipment comprising a launcher organization, and the assets and attributes of the equipment:

| Vehicles (5 types) | |
|--------------------|--|
| 1 | LR capacity, tons |
| 2 | Fuel capacity, gallons |
| 3 | Fuel type |
| 4 | Fuel consumption, MPG |
| 5 | Speed, MPH |
| 6 | Mean Time Between Failures (MTBF) |
| 7 | Vehicle hauling capacity (cubic feet and tons) |
| 8 | Vulnerability number (used to measure the vehicle's susceptibility to explosion blast effects) |
| 9 | Radiation protection factor |

*Symbolics is a trademark of Symbolics, Inc.

†KEE is a trademark of IntelliCorp of Mountain View, California.

| Electrical Generators (4 types) | |
|---------------------------------|--------------------------|
| 1 | Capacity, kW |
| 2 | Fuel consumption, gal/hr |
| 3 | Fuel type |
| 4 | Weight, tons |
| 5 | MTBF, hours |

| Radios (3 types) | |
|------------------|---------------------------------------|
| 1 | Minimum and maximum broadcast range |
| 2 | Minimum and maximum frequency range |
| 3 | Power consumption, kW |
| 4 | Type of data, digitized (BAUD), voice |

| ADP Equipment (2 types) | |
|-------------------------|---|
| 1 | Electromagnetic Pulse (EMP) vulnerability |
| 2 | MTBF |
| 3 | Power consumption, kW |

Actors (Entities) in the Model

The following is a list of the suite of actors, or entities that the model uses to represent the proposed MICBM system:

- (1) **Launcher Organizations**, 1 to N may be represented within the model.
- (2) A **Command Actor** represents a fixed hardened command post. Other actors (**Launcher Organizations**, **Supply Teams**, **Reconnaissance Teams**) communicate with the **Command Actor** via radio or land line. This actor can grant or deny requests from other actors, or order other actors to action.
- (3) A **Threat Actor** represents enemy intelligence. It possesses a suite of sensors (overhead detection systems, radio direction finding systems, etc.) that can detect **Launcher Organizations** or other mobile actors, or fixed depot sites. Upon detection, this actor has the capability to launch a nuclear attack against the actor, or a depot.
- (4) A **Terrain Advisor/Master** performs two functions. First, it maintains the ground truth regarding the "world" of the model. All information regarding sites, routes, actors, etc., damaged or destroyed by conventional or nuclear attack is maintained by the **Terrain Master**.
Second, the **Terrain Advisor** responds to an actor's request for route information utilizing the actor's perceptions of the "world".
- (5) A **Pseudo-Actor** represents an information net whereby observations made by civilians, ham radio operators, police, etc., can be broadcast to any actor within receiving range. These observations may be of damaged or destroyed sites, cities, highways, or other actors.

Other actors represented within the simulation include supply sergeants, motor sergeants, communication centers, and ADP personnel.

The Simulation Environment

The desired simulation environment would blend traditional discrete event simulation techniques with expert system-like capabilities to execute the complex decision-making events. In order to realistically represent the behavior of a military operation, the model must have the ability to maintain the "ground truth" regarding the operation, as well as the individual entities' perceptions of the truth. Further, the entities must be able to learn, as facts regarding the operation become known to them. For example, a town containing a fuel depot might have been destroyed by the enemy. However, this fact is unknown to an entity in the simulation requiring fuel. His decision process regarding where to send a re-fuel team could therefore cause him to dispatch his team to the destroyed depot. Upon arrival, the re-fuel team would then have access to the "ground truth" concerning the status of the depot, and his perception of the depot's status can be updated.

The hardware that was selected for this project was a Symbolics 3600 with 1 megaword of memory and a 300 megabyte disk. KEE was chosen as the software with which to implement the simulation. Utilizing KEE's ability to interface with the Symbolic's native Zetalisp, a discrete event simulation controller was written in LISP to drive the simulation. The complex C² (Command and Control) events were written in KEE's RuleSystem2. The less complex physical events (such as a refueling operation) were coded in LISP and invoked as KEE methods. The suite of actors (entities) within the model were defined by KEE units.

Operational Concept and Problem Statement

To the largest extent possible, it was desired that the design of the simulation allow the specification of the operational concept to remain flexible and easily changed. This was accomplished by defining the C² (decision-making) events in KEE's RuleSystem2. The natural-language syntax of KEE's RuleSystem2 is more easily learned and understood than LISP code. In this way the client can change any aspect of the operational concept by simply changing the rules defining the event of interest.

The problem statement to be answered by this prototype simulation is as follows:

How survivable and effective is the MICBM system in the event of global nuclear war?

To answer this question, the model reports the following information:

- (1) Numbers of launchers damaged or destroyed before they could carry out their mission,
- (2) Numbers and types of personnel losses,
- (3) Amount of communications traffic that was not received, and
- (4) Information regarding enemy detection.

Participants

Darrell Morgeson (S-6) was the project leader. Douglas Roberts (S-6), was responsible for the overall design and software engineering for the project. Jared Dreicer (S-6) designed the decision-making (C²) events. Kathy Burris (S-6) and Jan Steitzer (S-6) provided programming support.

Funding History

This was the first year of the project and no previous funding had existed for it. The funding for the project was \$500K.

ACCOMPLISHMENTS

The following has been accomplished on the MICBM simulation during the past fiscal year:

- (1) The **Software Requirements Document** was developed and reviewed by staff.
- (2) The **Preliminary Design Document** was also developed and reviewed by staff.
- (3) The **Detailed Design Document (Pseudo-code)** has been developed.
- (4) A working prototype of the model is running on the Symbolics 3600 computer.

Through this project, much has been learned regarding the capabilities of an object-oriented code development environment (Symbolics/KEE) for producing C³ simulations. Some of the features of this environment that were investigated during the development of the simulation were:

- (1) **Message passing** between objects (units) in the model
- (2) **Inheritance** roles from class units to subclass units
- (3) Use of the **KEE RuleSystem2** to capture human decision-making processes
- (4) Use of **Zetalisp** to code the simulation controller and the physical events

As a result of this project, the investigators feel that the capability to develop and implement the difficult C³ class of simulations on the Symbolics class of computers has been demonstrated. Further, it has been shown that these simulations can be developed much more rapidly than in the traditional FORTRAN environment. Benchmarks established during the course of the project show that LISP code can be developed on a Symbolics approximately five times faster than equivalent FORTRAN code generated in a more traditional computing environment.

In addition, the Symbolics/KEE environment is richer than other traditional simulation environments such as SLAM, SIMAN, GPSS, and SIMSCRIPT. Combining an artificial intelligence shell like KEE with a powerful object-oriented programming language like Zetalisp can result in a discrete event modeling capability superior in many ways to others currently in

existence. The authors are satisfied with the results of the prototype MICBM simulation and are preparing general "how-to" documentation for designing such simulations.

However, it was learned that there are some disadvantages to this environment. First is the speed (or lack thereof) in model execution. Second is the lack of any of the discrete event modeling tools such as a simulation controller or a library of probability density functions.

FUTURE PLANS

A natural follow-on study will be to investigate using AI techniques to develop a Planner. This planner will simulate the decision-making capabilities of a commander in combat. We expect that the product of this research will be very useful in enhancing the overall capability of our combat simulations in the performance of analysis for studying the effect of weapons system on the battlefield.

We have briefed numerous DOD officials on our results, including the Undersecretary of the Army. The Army has agreed to station two full-time Army Military Research Associates with S-5 to participate in research on command and control during the coming years.